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Large Hadron Collider
Magnet Division Specification

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Class: Ancillary Specifications
Title: Cold Rolled Magnet Steel for LHC Dipole Yoke Laminations

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REVISION RECORD

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A	10/28/98		Initial Release.	

1. Scope:

This specification covers the requirements for extra low carbon, cold-rolled electrical steel used for superconducting magnet yoke laminations. The material will be used at a cryogenic operating temperature near 4.5K with magnetic induction in the range of 0.05T to 3.8T.

2. Applicable Documents:

The following documents of the issue in effect on the date of invitation to quote form a part of this specification to the extent specified herein.

ASTM E18 - STD test methods for Rockwell Hardness

ASTM A596 - STD test method for D.C. magnetic properties of materials using ring test procedures and the ballistic methods

ASTM A568 - Steel, carbon and high-strength low-alloy hot-rolled sheet, hot-rolled strip and cold-rolled sheet, general requirements.

FED. SPEC. TT-C-490 Cleaning Methods and Pretreatment of Ferrous Surfaces for Organic Coatings

3. Requirements:

Extra low carbon electrical steel sheet offered by the Seller under this specification number shall meet the following physical properties and inspection and test requirements.

3.1 Chemical Properties:

3.1.1

Chemical Composition	%
Carbon	0.006 max
Manganese	0.1 - 0.3
Phosphorus	0.02 max
Sulfur	0.015 max
Silicon	0.05 max
Aluminum	0.08 max
Nitrogen	0.008 max

Total of all other impurities not to exceed 0.2%

3.2 Mechanical and Physical Properties:

3.2.1 Hardness: Rockwell B20-50 determined per ASTM E18. Rockwell B hardness shall not vary by more than 10 points in any given coil.

3.3 Magnetic Properties: Reproducible magnetic properties at both high and low fields is desired. The material should be processed to optimize its magnetic properties. Reproducible low coercive force, high permeability in the low induction region and reproducible intrinsic saturation induction are the desired magnetic properties.

3.3.1 Coercive Force: The coercive force (H_c) of the material shall be measured after it is excited by a magnetic force of 100 Oersted. No value of H_c shall differ from the average value of H_c over the entire production run by more than 0.25 Oersted, and no value of H_c shall exceed 2.3 Oersted.

3.3.2 Permeability, Low Field: The permeability at a magnetizing force of 1 Oersted shall be greater than 500.

3.3.3 Saturation Magnetization: A high and very uniform saturation magnetization is necessary. Since variation in saturation magnetization is caused mainly by variations in impurity content, strict impurity limits as stated in paragraph 3.1 are required.

3.4 Dimensions, Surface Quality, and Material Characteristics:

3.4.1 The finished thickness of the material shall be:

.0598 ± .005 (16 gauge sheet)

3.4.2 Permissible variations: As per the standard tolerance for ASTM carbon steel sheet.

3.4.3 Coil Width After Slitting shall be 25.25$\pm$.015 in.

3.4.4 Surface Quality (General): The surface shall be free from pits, seams, rust, scale marks, laminations, die breaks and other injurious defects which due to their nature, degree, or extent, will interfere with the use of the material.

3.4.5 Surface Treatment: The steel surfaces shall be treated with AISI Core Plate C-4 coating (Aluminum Pyrophosphate) or Iron Phosphate per TT-C-490 Type II, or other equivalent, BNL-approved coating.

3.4.6 Surface Finish: 30-60 micro-inches.

3.4.7 Edges: Slit. Minimal burr.

3.4.8 Max Crossbow shall be .026 in. across the entire width.

3.4.9 Max Camber: 1/32 in. in any 4 ft. length.

3.4.10 Max Crown shall be: 0.002 (in.) or less over full width of master coil.

3.4.11 Stretcher Leveling: Required.

4. Quality Assurance Provisions:

By making a shipment of magnet steel, the Seller automatically certifies that the steel shipped and all processes applied to the steel comply with this specification and the requirements of the purchase order. The Seller agrees to retain objective evidence, including records, of the inspections and tests performed in the course of manufacturing, testing, inspecting, preserving, packaging, and preparation for shipment of the steel. These records shall be made available to the Buyer's representative for review upon request.

Responsibility for the performance of the following inspections, test and data requirements rests with the material manufacturer. Unless otherwise specified, each heat of finished material shall be subjected to the following inspections and tests.

4.1 Chemical Composition: A determination of the material conformity with the requirements of 3.1, Chemical Composition.

4.2 Mechanical Properties: A determination of the material conformity to:

Rockwell Hardness: Paragraph 3.2.1

4.3 Magnetic Properties: A determination of material conformity to:

Coercive Force: Paragraph 3.3.1

Permeability, Low Field: Paragraph 3.3.2

Permeability, High Field: Paragraph 3.3.3

4.4 Non-conforming Material: Material not meeting the requirements of this specification shall not be offered to the Buyer.

4.5 Certificate of Conformance: With each shipment of magnet steel, the Seller shall submit a certificate of conformance. In case of drop shipment, a copy of the certificate shall be submitted to the Buyer at the time of shipment. The certificate shall be signed by an officer of the company, and shall constitute a representation by the Seller that:

A. Materials used are those which have been specified by the Buyer, and that the items delivered were produced from materials for which the Seller has on file reports of chemical or physical analysis, or any other equivalent evidence of conformance of such items to applicable specifications;

B. Processes used in the fabrication of items delivered were in compliance with applicable specifications forming a part of the purchase order, of Buyer approved procedures of specifications;

C. The items as delivered comply with all specifications and other requirements of the purchase order.

4.6 Material certification is required. One copy of actual chemical and physical test report(s) (refer to paragraphs 4.1 to 4.3) for each heat, batch or lot shall accompany each shipment. Test reports shall list the actual parameters tested, and shall contain the actual readings taken during test.

4.7 Upon the request of the Buyer, the Seller shall furnish a B-H table which includes magnetic measurements acquired within the range of 1 oersted to 3000 oersted inclusively.

5. Preparation for Delivery:

5.1 Marking Identification Requirements: Each slit coil shall be identified with at least the following data.

LHC-MAG-M-1002-A - Cold Rolled Steel for LHC Magnet Yoke Laminations _____. Material Thickness (in.) _____. Slit Width (in.) _____. Buyer's P.O. No. _____. Manufacturer's Name _____. Supplier’s Coil No. (Serial No.) _____. Heat No.(s) _____. Net Weight of Coil _____.

5.2 Treatment and Packaging After Slitting:

5.2.1 Coils are to be coiled with a 20 to 24 in. inside diameter.

5.2.2 Preferred slit coil weights to be within 2500 and 3000 pounds each, regardless of slit width. Slit coils may be below 2500 pounds weight but may not be above 3000 pounds.

5.2.3 Identify the heaviest edge thickness of slit coils (due to crown in master coil) by spray paint on the side of the coil with the heaviest edge thickness.

5.2.4 Cross breaks not permitted in slit coils.

5.2.5 Shipping of coils - Wrap individual coils in rust inhibiting paper, packed with desiccants and covered with plastic for protection. Ship coils eye up securely banded to pallets.